

***Attheyella (Canthosella) thailandica* sp. nov. (Copepoda, Harpacticoida, Canthocamptidae) from caves in Thailand**

Santi Watiroyram¹

¹ Division of Biology, Faculty of Science, Nakhon Phanom University, Nakhon Phanom 48000, Thailand

Corresponding author: Santi Watiroyram (santi.watiroyram@npu.ac.th)

Academic editor: Sanda Iepure | Received 12 June 2020 | Accepted 16 November 2020 | Published 28 January 2021

<http://zoobank.org/BFA1D6C0-BB58-4EFD-9E66-524BA6019073>

Citation: Watiroyram S (2021) *Attheyella (Canthosella) thailandica* sp. nov. (Copepoda, Harpacticoida, Canthocamptidae) from caves in Thailand. Subterranean Biology 37: 57–73. <https://doi.org/10.3897/subtbiol.37.55376>

Abstract

During this sampling campaign, the canthocamptid *Attheyella (Canthosella) thailandica* **sp. nov.** was collected from various caves in Thailand. The new species is widely distributed in the country and favours habitats, such as phytotelmata and wet soil. *Attheyella (Canthosella) thailandica* **sp. nov.** is the second member of the genus to be found in Thailand, after *Attheyella (Canthosella) vietnamica* Borutzky (1967), which is most similar to it. Amongst Asian species, both *A. (C.) thailandica* **sp. nov.** and *A. (C.) vietnamica* have identical setal formulae, with a greater number of armatures on the distal endopods of legs 2–4. However, *A. (C.) thailandica* **sp. nov.** markedly differs from *A. (C.) vietnamica* in the insertion point of the dorsal seta and the presence of inner spinules on the caudal ramus. Additionally, the leg 4 endopod is two-segmented in *A. (C.) thailandica* **sp. nov.**, but one-segmented in *A. (C.) vietnamica*.

Keywords

Morphology, phytotelmata, southeast Asia, taxonomy, wet soil

Introduction

The genus *Attheyella* Brady, 1880 is found in a wide range of habitats in various water bodies and often in groundwater (Chang and Kim 1992). The subgenus *Attheyella (Canthosella)* Chappuis, 1931 is one of the five subgenera of *Attheyella* and contained

15 valid species: *A. (C.) acanthophora* (Delachaux, 1924); *A. (C.) aliena* Noodt, 1956; *A. (C.) antillica* (Petkovski, 1973); *A. (C.) chocoensis* Gaviria & Defaye, 2012; *A. (C.) fluviatilis* Chappuis, 1931; *A. (C.) kalima* (Delachaux, 1924); *A. (C.) lacustris* Chappuis, 1931; *A. (C.) mervini* Janetzky, Martinez Arbizu & Reid, 1996; *A. (C.) muscicola* (Chappuis, 1928); *A. (C.) pilagaensis* Janetzky, Martinez Arbizu & Reid, 1996; *A. (C.) silvicola* Löffler, 1973; *A. (C.) siolii* (Kiefer, 1967); *A. (C.) stiblingi* (Reid, 1990); *A. (C.) vera* Por & Hadel, 1986 and *A. (C.) vietnamica* Borutzky, 1967 (Walter and Boxshall 2020). To date, six species of the subgenus *Canthosella* have been originally described from southeast Asia (SEA): three species from Indonesia [*A. (C.) fluviatilis*, *A. (C.) lacustris* and *A. (C.) muscicola*] and one species each from Malaysia [*A. (C.) silvicola*], Vietnam [*A. (C.) vietnamica*] and Thailand [*A. (C.) thailandica* sp. nov.], respectively. In Thailand, the first *Attheyella* species found in a cave, *A. (C.) vietnamica*, has been collected in northern Thailand (Watiroyram et al. 2015) and the second species of the genus found in a cave of the country is described herein as *A. (C.) thailandica* sp. nov.

Material and methods

This research mainly focused on cave-dwelling copepods in freshwater from the epikarst zone and related habitats – especially water dripping from rocks and plants at cave entrances (Fig. 1). Samples were collected using a filtering bottle with a mesh size of 60 µm and were preserved immediately in 70% ethanol. In the laboratory, samples were rinsed with tap water through a sieve with 60 µm mesh size. Adult specimens were sorted under an Olympus SZ51 stereomicroscope at 40× magnification and were placed in a mixture of glycerol and 70% ethanol (ratio ~ 1:10 v/v) to pure glycerol. Animals were dissected and prepared on a glycerine-mounted slide under a stereomicroscope at 40–100× magnification. The specimens were mounted in pure glycerine on a glass slide and were sealed under a cover glass with transparent nail varnish. Whole specimens were stored in 70% ethanol.

All appendages and body ornamentation were examined with 1000× magnification under an Olympus CX31 compound microscope. Drawings were made using an Olympus U-DA drawing tube mounted on the microscope. Final versions of the drawings were done using the CorelDRAW 12.0 graphic programme.

Specimens for scanning electron microscopy (SEM) were dehydrated in an ethanol series (50%, 70%, 80%, 90%, 95%, 100% and 100%) for 15 min at each concentration. Specimens were dried in a critical point dryer and mounted on stubs. Mounted specimens were coated with gold in a sputter-coater. SEM photographs were carried out using a LEO 1450VP scanning electron microscope.

Abbreviations used are: Enp, endopod; Exp, exopod; Exp/Enp-n, exopodal segment n/endopodal segment n; P1–P6, legs 1–6; s, spine; a, aesthetasc; NHMUK, the Natural History Museum (United Kingdom); NPU, Nakhon Phanom University, Faculty of Science (Thailand).

The descriptive terminology follows Huys and Boxshall (1991).

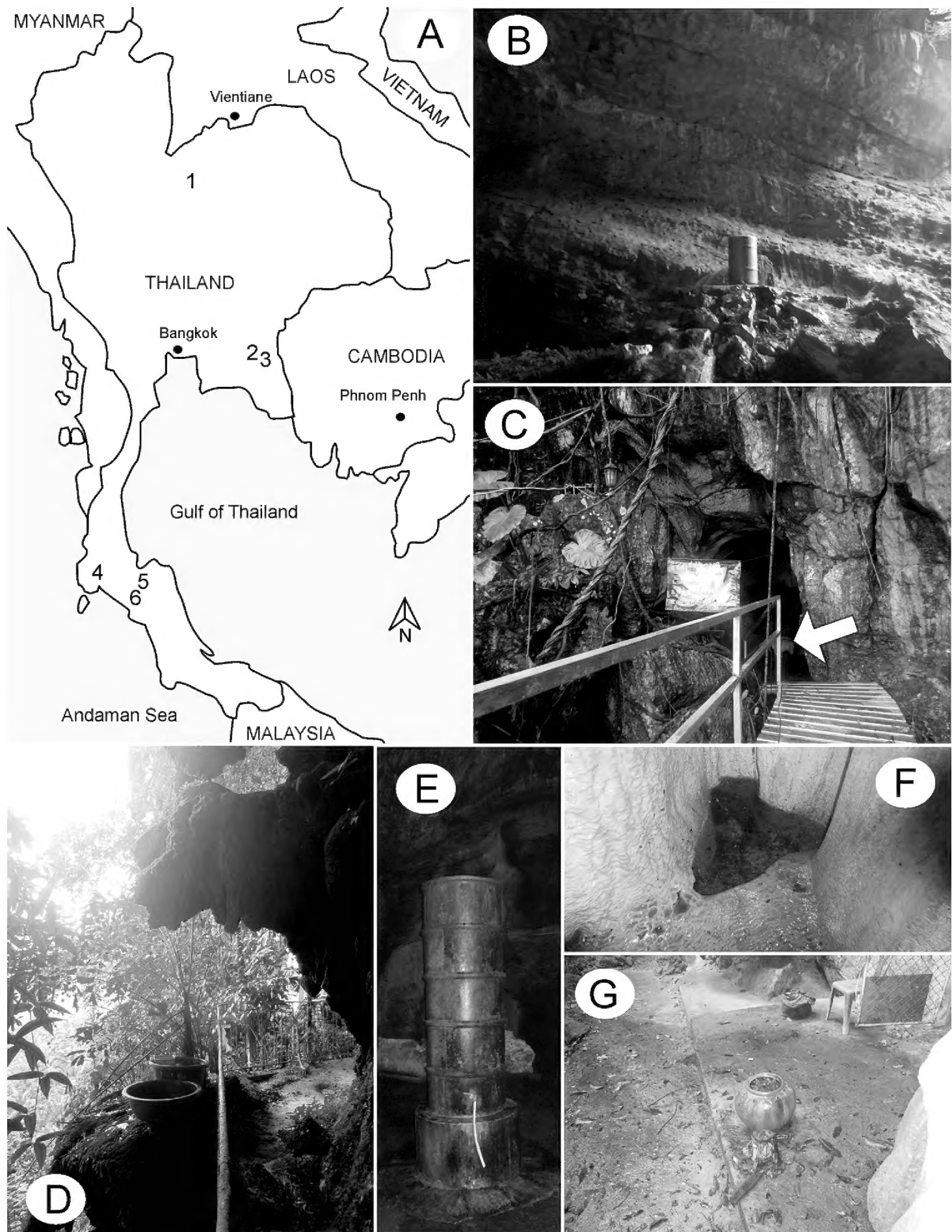


Figure 1. Distribution of *Attheyella* (*Canthosella*) *thailandica* sp. nov. **A** black circle = capital city, Arabic numbers refer to sampling caves: 1, Huang Po cave; 2, Khao Chakan cave; 3, Plub Pleung Thong cave; 4, Payanakarat cave; 5, Pra Hor cave; 6, Mae-nang Songsri cave **B** Huang Po cave **C** Plub Pleung Thong cave (white arrow indicates water container with the new species) **D** Payanakarat cave **E** Mae-nang Songsri cave **F** Khao Chakan cave **G** Pra Hor cave.

Taxonomic section

Family Canthocamptidae Brady, 1880

Genus *Attheyella* Brady, 1880

Subgenus *Canthosella* Chappuis, 1931

***Attheyella* (*Canthosella*) *thailandica* sp. nov.**

<http://zoobank.org/CE4F2A69-0F23-4EB7-B84B-33A29FC75F8E>

Figures 2–7

Other localities. Mae-nang Songsri cave, Hin Tok Subdistrict, Ron Phibun District, Nakhon Si Thammarat Province, southern Thailand: 08°14'45"N, 99°52'01"E, 45 m altitude, 29 October 2015; Payanakarat cave, Tham Thong Lang Subdistrict, Thap Put District, Phang Nga Province, southern Thailand: 08°31'11"N, 98°33'57"E, 140 m altitude, 5 November 2014; Khao Chakan cave, Khao Chakan Subdistrict, Khao Chakan District, Sa Kaeo Province, eastern Thailand: 13°39'36"N, 102°05'04"E, 120 m altitude, 1 September 2017; Plub Pleung Thong cave, Wang Mai Subdistrict, Wang Sombun District, Sa Kaeo Province, eastern Thailand: 13°26'50"N, 102°13'03"E, 223 m altitude, 31 August 2017. All samples were collected by the author.

Type localities. Huang Po cave, Thung Na Lao Subdistrict, Khon San District, Chaiyaphum Province, north-eastern Thailand: 16°35'25"N, 101°49'28"E, 384 m altitude, 16 October 2017; Pra Hor cave, Tham Yai Subdistrict, Thung Song District, Nakhon Si Thammarat Province, southern Thailand: 08°06'49"N, 99°43'59"E, 101 m altitude, 29 October 2015. Samples were collected by the author.

Etymology. The specific name of the new species, '*thailandica*', refers to Thailand, where the species was collected.

Type specimens. *Holotype*: one adult female dissected and mounted on one slide, NHMUK 2020.56; *Allotype*: one adult male dissected and mounted on one slide, NHMUK 2020.57; *Paratypes*: three adult females and three adult males not dissected and stored in a 1.5 ml microtube with 70% ethanol, NHMUK 2020.58–63; one adult female dissected and mounted on one slide, NPU 2020-003; one adult male dissected and mounted on one slide, NPU 2020-004; three adult females and three adult males not dissected and stored in a 1.5 ml microtube with 70% ethanol, NPU 2020-005.

Description of adult female (holotype). *Body* (Fig. 2A) cylindrical, with mean length 510 µm, measured from rostrum to distal rim of caudal rami (n = 5, range 500–530 µm). Cephalothorax with narrow, saddle-shaped, well discernible integumentary window; several sensilla scattered on dorso-lateral surface. Prosome and urosome (segments 1–4) with free posterior margins smooth dorsally; rows of minute spinules dorsally on prosomites 2–4, urosomites 1–2. Genital double-somite completely fused (Figs 2B, 4A), about 0.5× as long as wide, with row of strong dorso-lateral and ventral spinules along distal margin, mid-ventral bell-shaped copulatory pore, duct and receptacles. Urosomite 3 with row of spinules ventrally inserted near posterior edge, row interrupted mid-ventrally. Urosomite

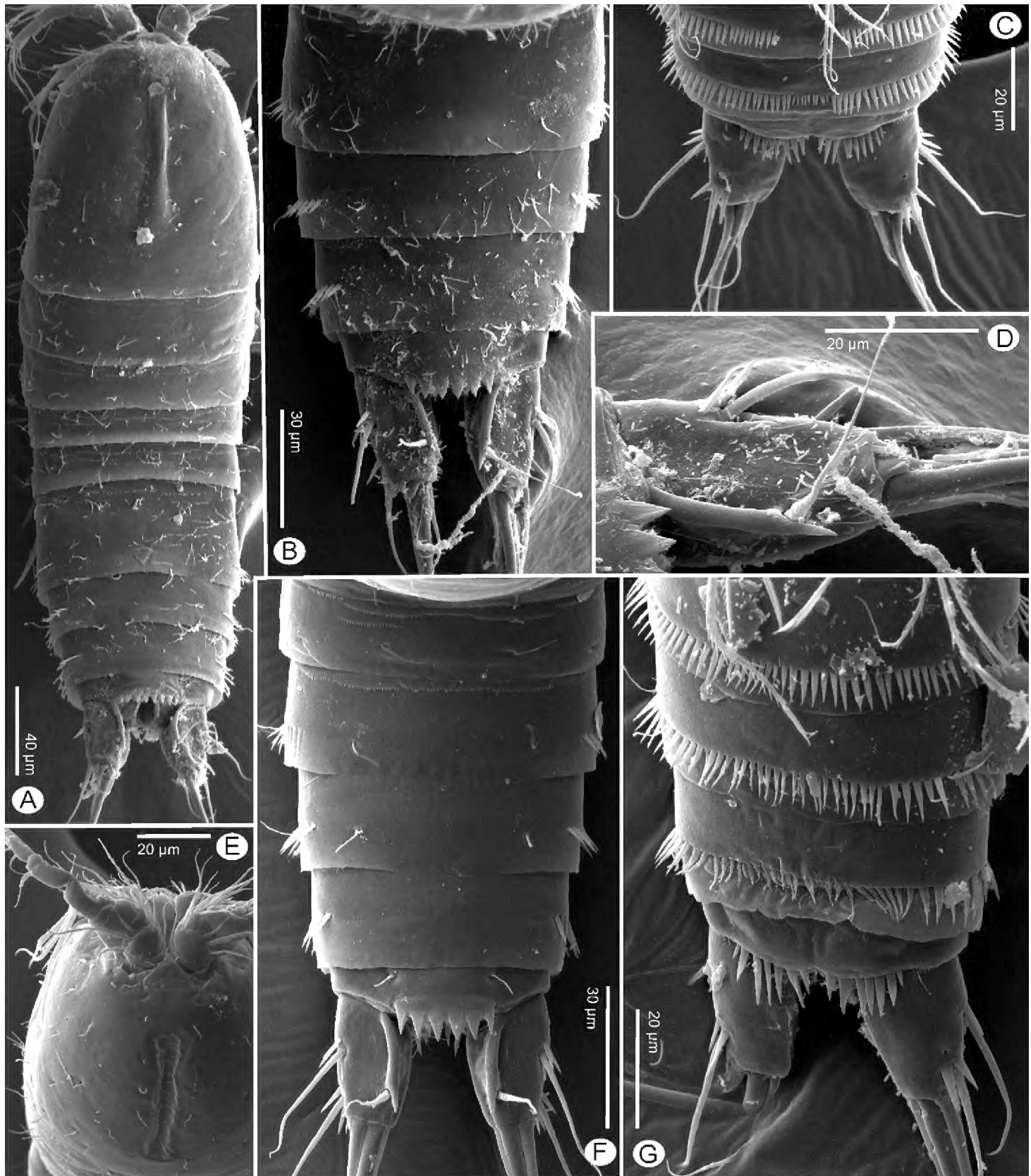


Figure 2. *Attheyella* (*Canthosella*) *thailandica* sp. nov., female (**A–D**) and male (**E–G**): **A** habitus, dorsal view **B** urosome without urosomite 1, dorsal view **C** urosomite 3–5, ventral view **D** caudal ramus, dorsal view **E** cephalothorax, dorsal view **F** urosome without urosomite 1, dorsal view **G** urosome without urosomite 1, ventral view.

4 with continuous row of spinules ventrally near posterior margin. Anal somite (Figs 2B, C, 4A, B) with one pair of sensilla dorsally above base of anal operculum; seven to ten spinules (nine in holotype) ventrally near insertion of each caudal ramus; anal operculum concave and well-developed, with six strong spinules on free posterior margin.

Caudal ramus (Figs 2A–D, 4A, B) conical, about 2.0× longer than wide, inner margin unornamented; longitudinal keel located along dorso-inner margin, ending in

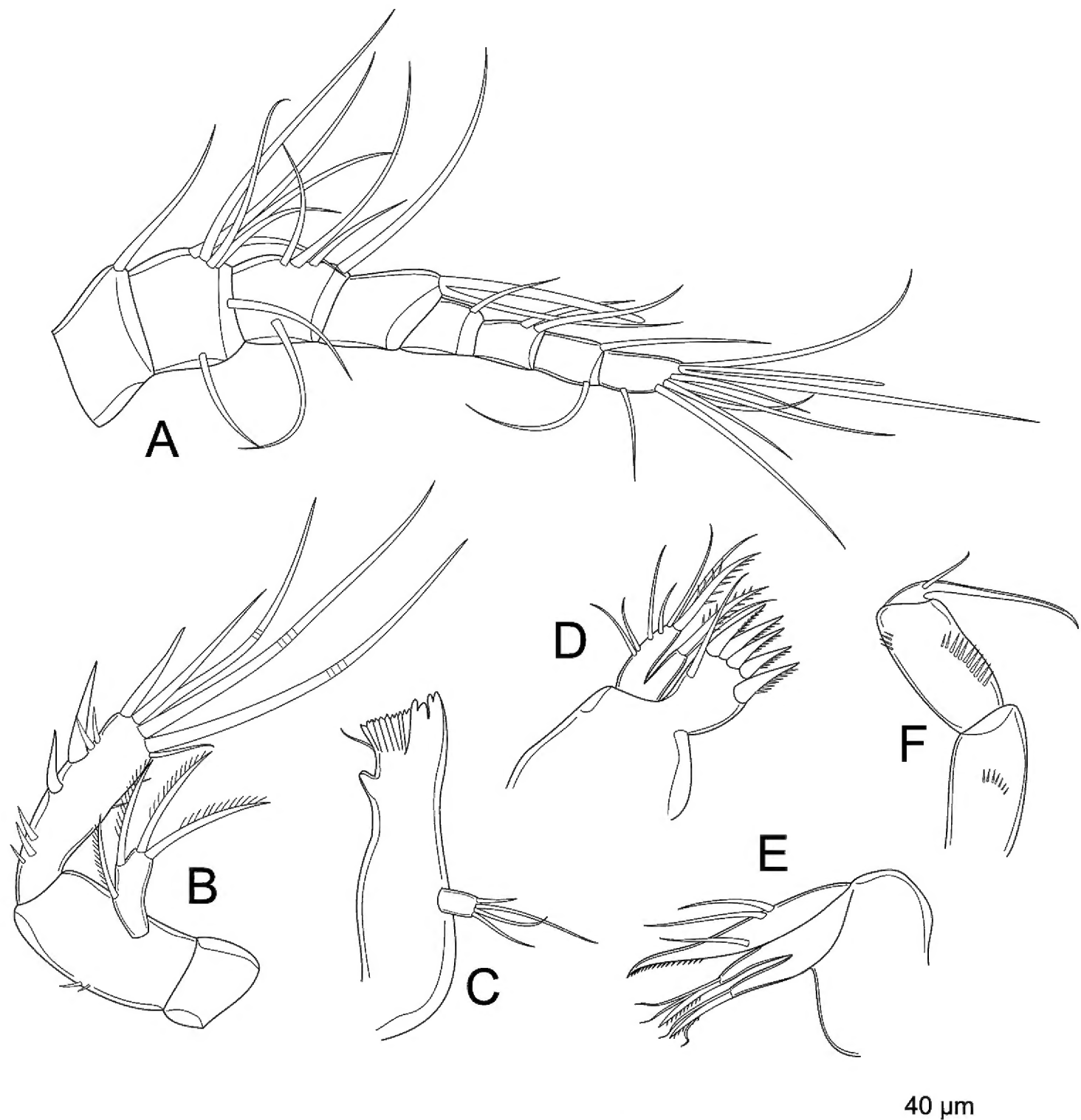


Figure 3. *Attheyella* (*Canthosella*) *thailandica* sp. nov., female: **A** antennule **B** antenna **C** mandible **D** maxillule **E** maxilla **F** maxilliped.

acute tip. Ramus with seven setae (setae I–VII), all smooth, except setae IV and V. Anterolateral accessory seta (I) small, inserted near seta II. Anterolateral seta (II) inserted at two-quarters of ramus, accompanied by two spinules, about 1.5× longer than ramus length. Posterolateral seta (III) inserted at three-quarters of ramus, accompanied by two to three (two in holotype) spinules, about 1.3× longer than ramus length. Outer apical seta (IV) unipinnate, without a breaking plane, about 1.7× longer than ramus length. Inner apical seta (V) longest, bipinnate, without a breaking plane, more than 5.0× longer than ramus length. Inner accessory seta (VI) shortest, about as long as ramus length. Dorsal seta (VII) articulated, inserted on distal end of dorsal keel at three-quarters length of ramus, about 1.6× longer than ramus length.

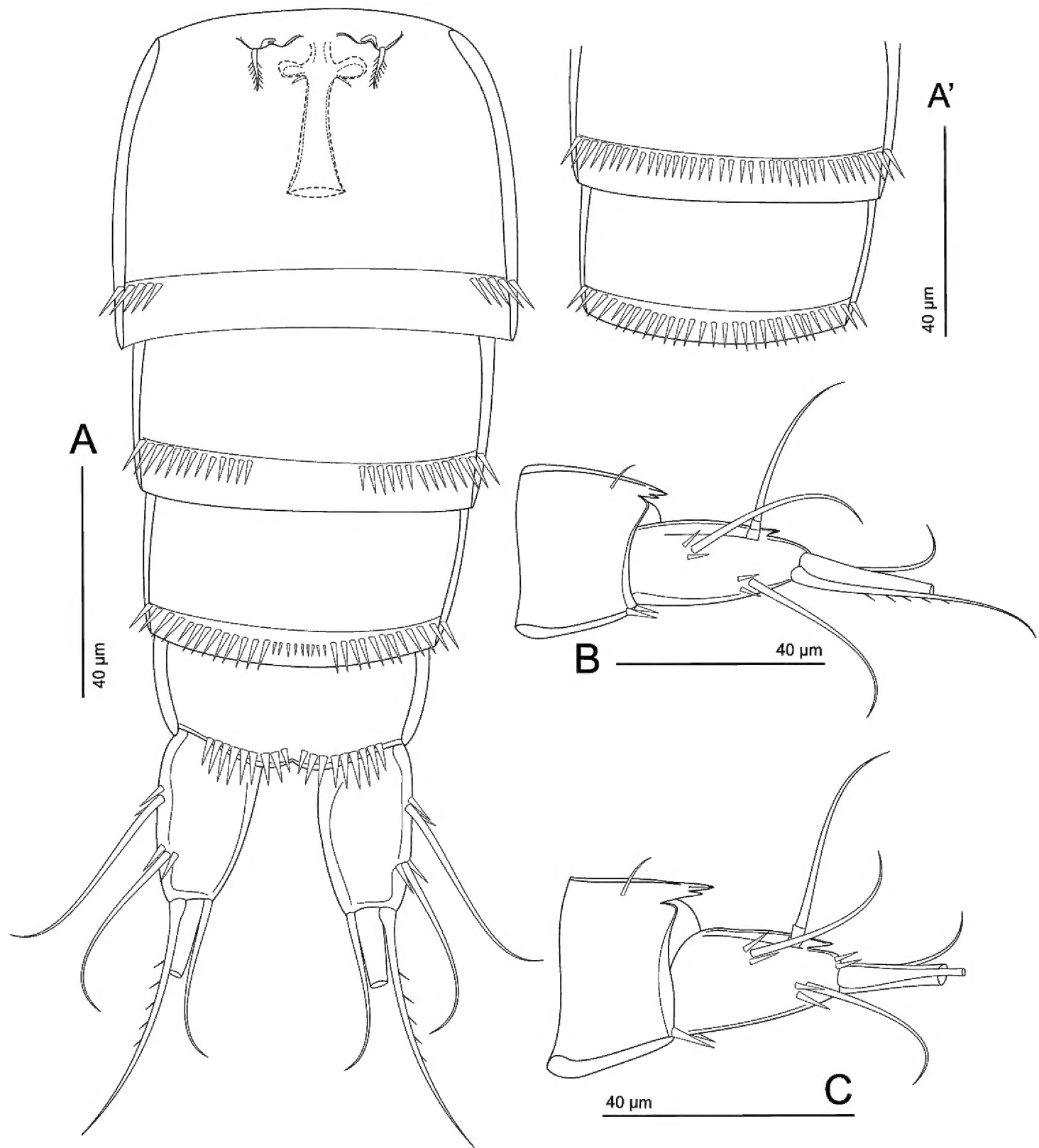


Figure 4. *Attheyella* (*Canthosella*) *thailandica* sp. nov., female (**A**, **B**) and male (**C**): **A** urosome without urosomite 1, ventral view (**A'** variation on urosomite 3–4, from type locality) **B**, **C** anal somite and caudal ramus, lateral view.

Antennule (Fig. 3A) eight-segmented, with setal formulae as follow: 1(I), 8(II), 5(III), 1+a(IV) with conjoined bases, 1(V), 2(VI), 2(VII), 7 and 1+a(VIII) with conjoined bases (Arabic and Roman numerals refer to number of setae and segment number, respectively). Aesthetasc cylindrical; both aesthetascs fused at their bases with a seta forming an acrothek. All setae slender, smooth.

Antenna (Fig. 3B) with small, unarmed coxa. Allobasis elongated, with two spinules on abexopodal margin. Exp one-segmented, with two inner and two apical unipinnate setae. Enp one-segmented, with two outer spines, one apical spine and five

apical setae (two normal and three geniculated setae); inner and outer margins ornamented with two rows of spinules.

Mandible (Fig. 3C) with two large teeth, seven small teeth distally and one lateral seta on gnathobase, with a small knob on the disto-lateral margin. Palp one-segmented, with four apical setae.

Maxillule (Fig. 3D) with five apical spines and one anterior seta on praecoxal arthrite. Coxal endite with one spine and one seta apically. Basis with one spine, two setae apically. Exp and Enp reduced, represented by four lateral setae on basis.

Maxilla (Fig. 3E) with two endites on syncoxa, each endite with three apical setae. Basis elongated, drawn out into a claw, with one proximal accessory seta. Enp reduced and represented by two setae.

Maxilliped (Fig. 3F) with unarmed coxa, ornamented with row of spinules on median surface. Basis with two groups of spinules at inner and outer margins. Enp one-segmented, transformed into claw-like segment, accompanied by one small seta inserted proximally.

P1–P4 with three-segmented Exp and two-segmented Enp. The armature formula is as follows (Arabic and Roman numerals indicate number of setae and spines, respectively; not including spinules):

	Coxa	Basis	Exp			Enp	
			1	2	3	1	2
P1	0-0	I-1	I-0	I-0	I-2-1	0-1	0-2-1
P2	0-0	I-0	I-0	I-1	II-2-1	0-0	0-I+1-0
P3	0-0	I-0	I-0	I-1	II-2-2	0-0	0-I+2-0*
P4	0-0	I-0	I-0	I-1	II-2-2	0-0	0-2-0

*the formula for the male P3Enp: Enp-1–3 is 0-0, 0-1, 0-2-0, respectively.

P1 (Fig. 5A) basis with short, strong outer spiniform spine and long, slender, smooth inner seta. Enp shorter than Exp; Enp-1 reaching to middle of Exp-2, with one inner unipinnate-tipped seta, ornamented with strong outer spinules and inner setules. Enp-2 with one smooth distal inner seta, one distal inner geniculated seta and one distal outer unipinnate seta; ornamented with strong outer spinules. Exp-1–2 with one distal outer spiniform spine; both segments ornamented with strong outer spinules. Exp-3 with one distal outer spiniform spine, two apical setae (inner seta geniculated, outer one unipinnate) and one distal inner geniculated seta; ornamented with few distal outer spinules.

P2 (Fig. 5B) basis with short, strong outer spine. Enp as long as Exp-1; Enp-1 shorter than wide, unarmed. Enp-2 with two elements apically; outer spine slightly longer than segment; inner seta bipinnate, long, extending beyond Exp. Exp-1 with one enlarged distal outer spine; ornamented with outer spinules. Exp-2 with one distal outer spine and one smooth distal inner seta. Exp-3 with two distal outer spines, two apical setae (inner seta bipinnate, outer one unipinnate) and one smooth inner seta; ornamented with disto-outer spinules.

P3 (Fig. 5C) basis with long, smooth, slender outer seta. Enp as long as Exp-1; Enp-1 shorter than wide, unarmed. Enp-2 with three elements apically; outer spine and innermost seta shorter than segment, subequal in length; middle seta bipinnate,

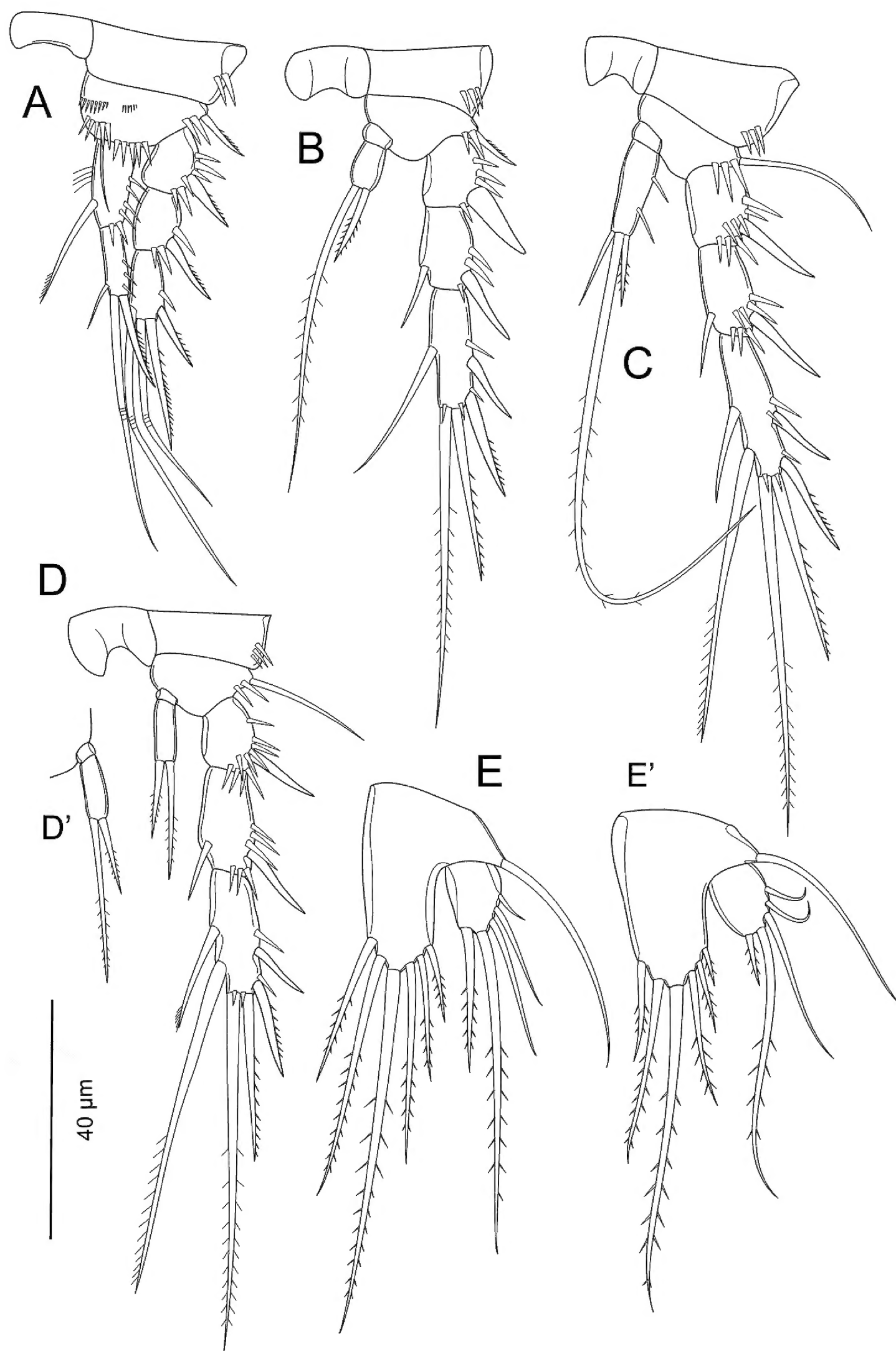


Figure 5. *Attheyella (Canthosella) thailandica* sp. nov., female: **A** P1 **B** P2 **C** P3 **D** P4 (**D'** variation) **E** P5 (**E'** variation, specimen from Pra Hor cave).

reaching beyond Exp. Exp-1–2 with one distal outer spine, ornamented with spinules along disto-outer margin; Exp-2 with one additional smooth distal inner seta. Exp-3 with two distal outer spines, two apical setae (inner seta bipinnate, outer one unipinnate) and two inner setae (distal seta unipinnate, about $3.0\times$ longer than proximal seta); ornamented with spinules along disto-outer margin.

P4 (Fig. 5D) basis and Exp as in P3, but Exp-3 shorter. Enp as long as Exp-1; Enp-1 small, shorter than wide, unarmed. Enp-2 with two bipinnate setae apically, both longer than segment; inner seta shorter than outer seta.

P5 (Fig. 5E) without ornamentation on surface. Basal seta smooth, slender. Baseoendopod separated from Exp, well-developed, exceeding Exp, with six spiniform setae; third inner seta longest apically; remaining setae decreasing in length to outer and inner margins of Enp. Exp sub-oval, with five setae, second inner seta longest; two innermost setae spiniform; three outer remaining setae smooth and decreasing in length to margin of Exp.

P6 (Fig. 4A) reduced to a single bipinnate seta inserted on the small plate, anterior to the seminal receptacle on the first half of genital double-somite.

Adult females with single egg sac containing 12–15 eggs (holotype: 12 eggs).

Description of adult male (allotype). *Body* length $510\ \mu\text{m}$ (Fig. 2E–G) from rostrum to distal rim of caudal ramus, $470\text{--}590\ \mu\text{m}$ ($n = 5$), smaller than female. Prosome (including antenna and mouthparts), anal somite and caudal ramus similar to those of female. Genital somite (Figs 2F, 6B) without row of posterior spinules; urosomites 3–5 with continuous posterior spinules along ventral to dorso-lateral sides.

Antennule (Figs 6–7A) ten-segmented, geniculated between segments 7 and 8. Segment 4 small, beneath segment 3. Setal formulae: 1(I), 7(II), 5(III), 2(IV), 3 and 1+a(V), 2(VI), 1(VII), 0(VIII), 0(IX), 7 and 1+a(X); aesthetasc on segments 5 and 10 fused to the base of seta, forming an acrothek. All setae smooth.

P1, P4 (Figs 6B, 7D) and P2–3 Exp similar to those in female. P2 (Fig. 7B) Enp slightly longer than Exp-1; Enp-1 shorter than wide, unarmed. Enp-2 with long bipinnate seta apically, with two to three spinules on outer margin. P3 (Fig. 7C) Enp three-segmented; Enp-1 shorter than wide, unarmed. Enp-2 with thin inner apophysis with harpoon-like tip, long, exceeding beyond Exp. Enp-3 with two apical setae; outer seta bipinnate, longer than Exp; inner seta smooth, thin, shorter than segment. P4 (Fig. 7D) Enp two-segmented; Enp-1 small, shorter than wide, unarmed; Enp-2 shorter than Exp-1, about $2.5\times$ longer than wide, with two bipinnate setae apically (outer seta longer than inner one; inner seta slightly longer than segment).

P5 (Figs 6C, 7E) separated from somite, baseoendopod of left and right sides fused medially. Basal seta long, slender and smooth. Baseoendopod separated from Exp, reaching one-half of Exp, with two spiniform setae; inner seta over $4.0\times$ longer than outer seta. Exp with four setae; second inner seta longest, followed by second outer seta, innermost seta and outermost seta, respectively; two inner setae bipinnate, two outer setae smooth.

Variability. (a) The free distal margin of the anal operculum varies from six to ten spinules in females and six to eight spinules in males, a characteristic which is,

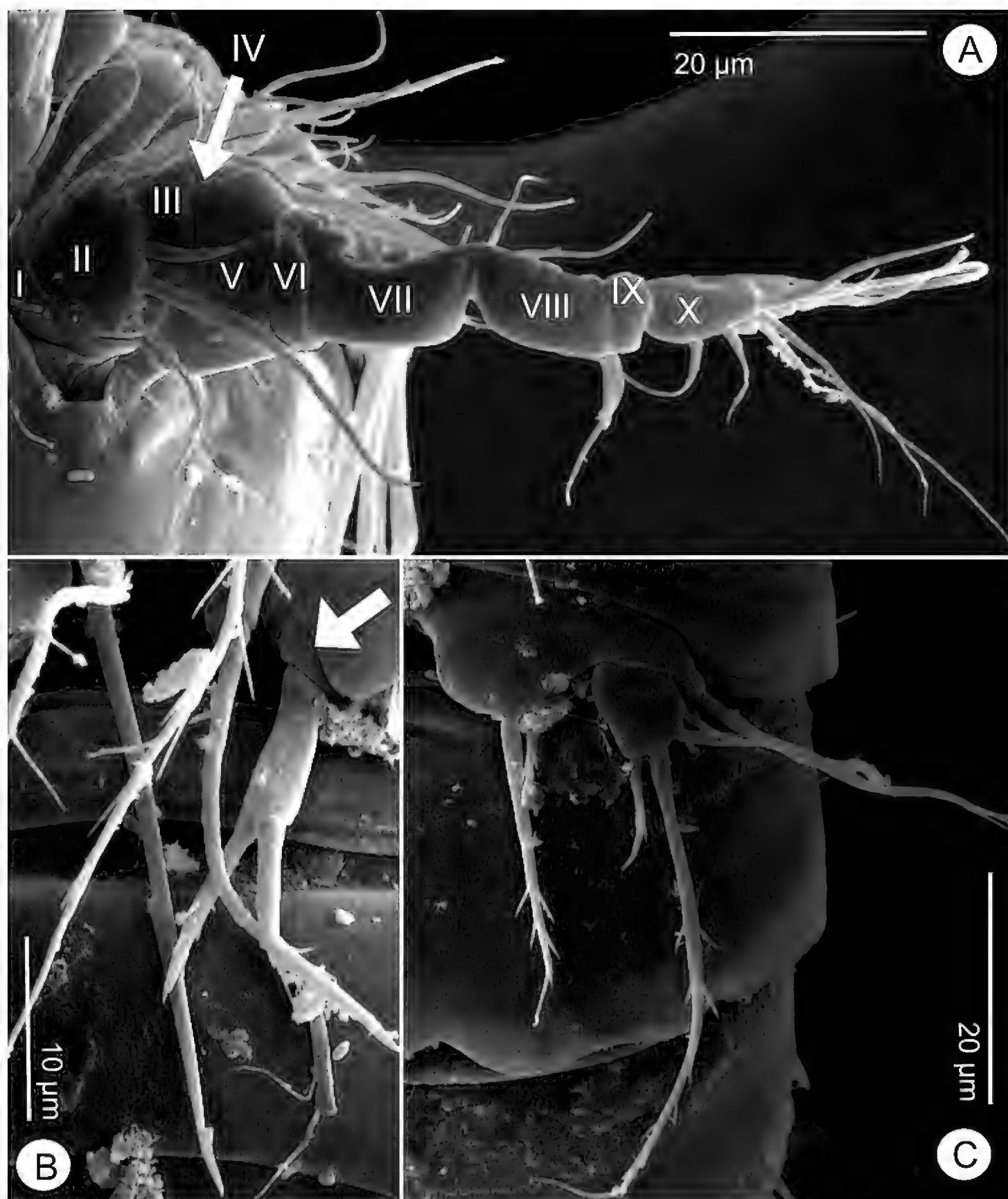


Figure 6. *Attheyella* (*Canthosella*) *thailandica* sp. nov., male: **A** antennule (white arrow indicates segment IV) **B** P4 Enp (white arrow indicates Enp-1) **C** P5 and P6.

perhaps, useless for differentiating amongst species, as mentioned by Gaviria and Defaye (2012). (b) The posterior margin of urosomite 3 in female has a continuous row of ventral spinules (Fig. 4A'; one of the other five examined specimens collected from the type locality). (c) The P2–P3 Enp-2 has a different number of spinules along the outer margin, with two spinules on P2 and three spinules on P3 in females (not shown in Figure; one of the other five female from the type locality) and with two spinules on P2 in males (Fig. 7B'; one of the other five examined specimens collected from the

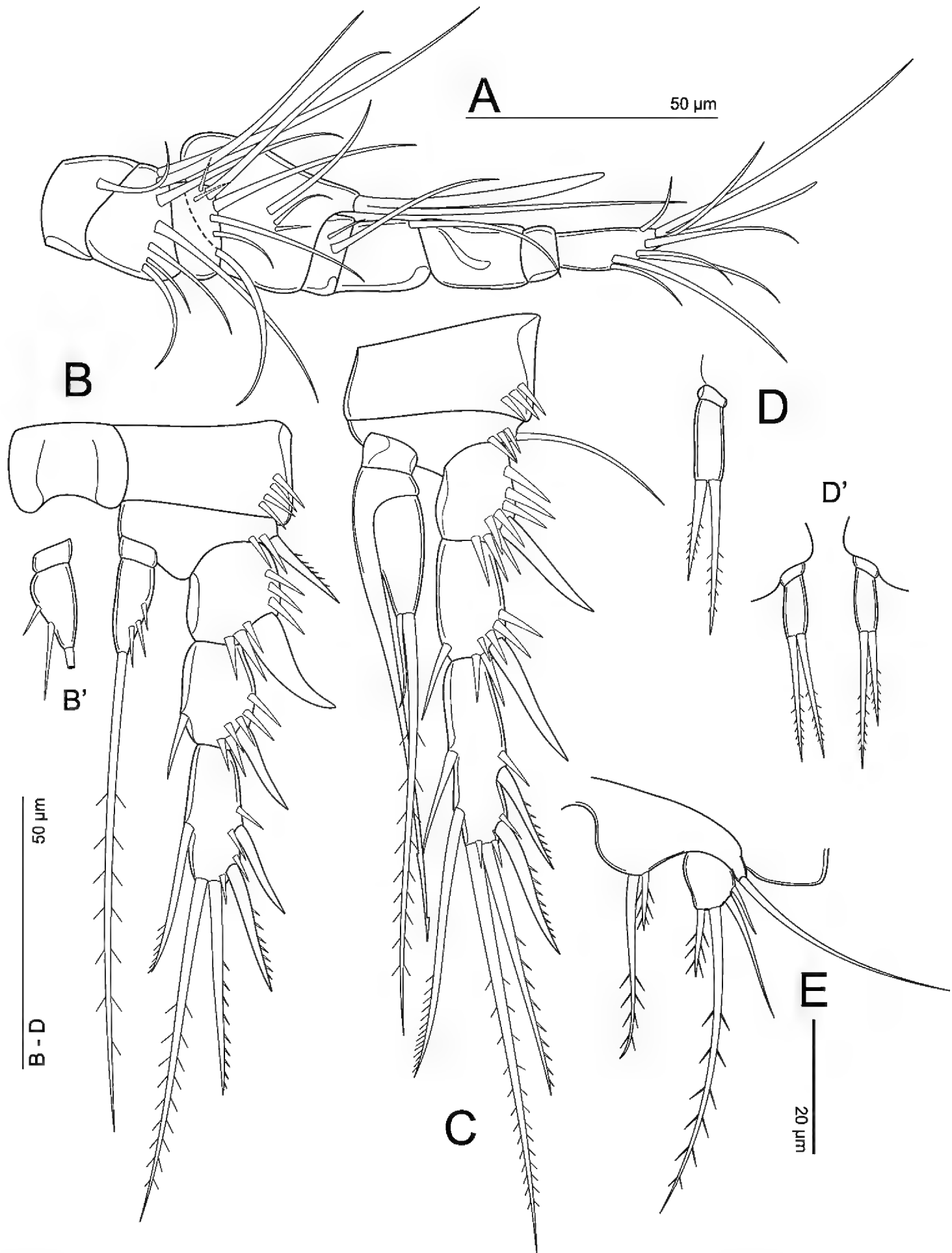


Figure 7. *Attheyella (Canthosella) thailandica* sp. nov., male: **A** antennule **B** P2 (**B'** variation, specimen from type locality) **C** P3 **D** P4 Enp (**D'** variation, specimen from Pra Hor cave) **E** P5.

type locality). (d) The seta size of the P4 Enp-2 in both sexes, the outer seta about 2.0× longer than the inner seta in female and the inner seta longer than or equal in length to outer seta in male (Figs 5D', 7D'; two of the other five examined specimens collected

from Pra Hor cave). (e) The female P5 in the southern population shows mostly shorter Exp and End setae (Fig. 5E'; two other females from Pra Hor cave).

Ecology. *Attheyella* (*C.*) *thailandica* sp. nov. is usually found in pools of water at cave entrances, where water seeps through soil and plants before flowing down into the cave (see Fig. 1B, D, G). In this research, some samples were found in a pool at the twilight zone of a cave (Fig. 1C) and in a pool in the dark zone of a cave, which was directly fed by the dripping water from stalactites (Fig. 1F). The favourite habitats of *A.* (*C.*) *thailandica* sp. nov. in the present study are likely to be phytotelmata or wet soils, as is already known from most species of *Attheyella* (subgenus *Canthosella*) (Reid 2001). At times, *A.* (*C.*) *thailandica* sp. nov. has been found together with *Bryocyclop muscicola* (Menzel, 1926); both are recognised as stygophile species and are widely distributed in Thailand (Watiroyram 2018; present study).

Discussion

Attheyella (*C.*) *thailandica* sp. nov. has been identified as belonging to the subgenus *Canthosella* Chappuis, 1931 because it shares the following characteristics with other members of the subgenus: posterior margin of somites smooth; caudal ramus longer than wide; antenna with one-segmented Enp; P1–P4 with two-segmented Enp (P1 Enp shorter than Exp, P4 Enp-1 much smaller than other legs of Enp-1); P2–P4 Enp-2 with at least two elements; male P3 with three-segmented Enp bearing an inner apophysis on Enp-2; male P4 Exp-3 without transformed spine; P2–P4 Exp-2–3 with at least one inner seta and one outer spine; female P5 baseoendopod well-developed (reaching beyond Exp) bearing six setae, while Exp bears five setae; male P5 with two setae on baseoendopod and four setae on Exp.

However, *A.* (*C.*) *thailandica* sp. nov. shows morphological differences from other species of the subgenus, related to the ornamentation of the caudal rami. Most species of *Attheyella* (*Canthosella*), except *A.* (*C.*) *antillica* and *A.* (*C.*) *mervini*, carry spinules on the inner margin of the caudal ramus (at least in the female). This margin is bare in both sexes of *A.* (*C.*) *thailandica* sp. nov.

At present, the *Canthosella* subgenus shows two lineages, which include ten American and six SEA species. They can easily be differentiated by the number of armatures on their P2–P4 legs. In contrast to SEA species, all American species, except *A.* (*C.*) *acanthophora*, show a higher number of setae on the P2–P4 Enp-2 in both sexes. Females of these American species have three to four, three to five or two elements on P2–P4, respectively – except for the P4 of *A.* (*C.*) *antillica*, which has one seta. Females of SEA species show one to two setae, one to three setae or one seta on P2–P4, respectively – except for the P4 of *A.* (*C.*) *vietnamica* and *A.* (*C.*) *thailandica* sp. nov., which carry two setae. Additionally, the male P3 Enp-3 of the American species shows two apical setae – except in *A.* (*C.*) *aliena*, which has only one seta. Males of the SEA species have only one seta on the male P3 Enp-3, except for *A.* (*C.*) *thailandica* sp. nov., which has two setae. However, a minute seta located close to a long distal seta on

Table 1. Morphological differences of the new species and the SEA species of the subgenus *Canthosella* Chappuis, 1931.

Species Characteristics	<i>A. (C.) fluviatilis</i>	<i>A. (C.) lacustris</i>	<i>A. (C.) muscicola</i>	<i>A. (C.) silvicola</i>	<i>A. (C.) vietnamica</i>	<i>A. (C.) thailandica</i> sp. nov.
Female						
Anal operculum	With 8 spinules	With 7 spinules	With 7–10 spinules	With 5–8 spinules	With 6 spinules	With 6–10 spinules
Caudal ramus (CU)						
– shape	Conical	Sub-rectangular	Oval	Conical	Conical	Conical
– Length/wide ratio	< 1.3	1.5	> 1.7	1.5	1.5	> 1.7
– Inner median margin	With spinules	With spinules	With spinules	With spinules	With spinules	Without spinules
– Insertion point of seta VII	??	??	??	3/4 of CU	Distal end of CU	3/4 of CU
P2–P4						
– segmentation	2.2.2	2.2.2	2.2.2	2.2.2	2.2.1	2.2.2
– Armature on distal Enp	1.1.1	2.2 ¹ .1	2.2 ² .1	2.2.1	2.3.2	2.3.2
P5						
– Baseoendopod	With spinules With 1 apical seta	With spinules With 1 apical seta	Without spinules With 1 apical seta	Without spinules With 1 apical seta	Without spinules With 2 apical seta	Without spinules With 1 apical seta
Male						
– Armature on P3 Enp-3	1	unknown	1	1	1	2
– Armature on P2 and P4 distal Enp	1 ³ .1	unknown	1.1	1.2 ⁴	1.2	1.2

¹ = Well (2007) holds that *A. (C.) lacustris* with three spines and setae, counting two apical setae and one inner seta (though the latter appears to be a spinule rather than a seta). However, Well (2007) does not count those similar elements on the inner margin of the P3 Enp-2 in *A. (C.) fluviatilis*. Therefore, the present study notes that *A. (C.) lacustris* has two apical elements. ² = *A. (C.) muscicola* has one apical seta and one outer seta, in contrast to *A. (C.) lacustris* with two apical setae. ³ = Well (2007) holds that *A. (C.) fluviatilis* has three spines and setae, probably by counting one apical seta and two small inner setae as described in Chappuis (1931). However, Well (2007) does not generally count armatures (like spinules) on the inner margin of *Attheyella* species described in Chappuis (1931), and the male P2 Enp-2 usually has the same number of armatures on its segment (or fewer) than females. Therefore, the present study notes that *A. (C.) fluviatilis* has one apical seta. ⁴ = An original description notes, in the leg formula, that the male P4 of *A. (C.) silvicola* has a two-segmented Enp, but it is presented as one-segmented Enp in the related Figure. Well (2007) notes that the male has a one-segmented Enp.

the male P3 Enp-3 could easily have been overlooked in previous descriptions (P.H.C. Corgosinho, personal communication).

Amongst the six SEA species, *A. (C.) thailandica* sp. nov. is most similar to *A. (C.) vietnamica* for the following reasons (Table 1). (a) The P3 Enp-2 of a female in these species bears three elements, while it only bears two elements in *A. (C.) lacustris*, *A. (C.) muscicola* and *A. (C.) silvicola* and has only one seta in *A. (C.) fluviatilis*. (b). The P4 Enp in both sexes bears two apical setae, while it bears only one seta in all other individuals, except the male of *A. (C.) silvicola*, which has two setae. (c) The P2 Exp-1 in both sexes of these species has an enlarged outer spine, but this spine is normal in the other species; this characteristic is presumed to be a synapomorphy, which can be used to define closely-related species.

Nevertheless, *A. (C.) thailandica* sp. nov. also shows strong morphological differences from *A. (C.) vietnamica* in the following aspects. (a) The P4 Enp is two-segmented in both sexes of *A. (C.) thailandica* sp. nov. (Fig. 6B), but one-segmented in *A. (C.) vietnamica*. (b) The female caudal ramus of the new species has no spinules on the inner margin, but these spinules are present in *A. (C.) vietnamica*. (c) The new species has a

dorsal seta located at three-quarters of the length of the caudal ramus, while this seta is located almost at the distal end in *A. (C.) vietnamica*. d) The male of the new species has two setae on the P3 Enp-3, while the male of *A. (C.) vietnamica* has one seta. e) *A. (C.) thailandica* sp. nov. exhibits a reduced Enp (especially P3) in both sexes, which are shorter in *A. (C.) vietnamica*. f). The morphology of P5 differs in several ways.

In the female of *A. (C.) thailandica* sp. nov., the innermost seta of the Exp is located at the (sub)distal margin, while it is obviously located at the inner margin in *A. (C.) vietnamica*. The new species has a third inner seta located at the apex of the baseoendopod, while this third inner seta and the third outer seta are located apically in *A. (C.) vietnamica*. The male of *A. (C.) thailandica* sp. nov. has a more developed P5 baseoendopod, in contrast to *A. (C.) vietnamica*, whose P5 baseoendopod reaches to one-third of the Exp. Thus, *A. (C.) thailandica* sp. nov. can be established as its own taxonomical unit new to science.

A key to worldwide species of the subgenus *Canthosella* Chappuis, 1931

Females

(female unknown for *A. (C.) siolii* and *A. (C.) sriblingi*)

1	P4 Enp one-segmented	2
–	P4 Enp two-segmented	4
2	Caudal ramus with inner margin produced into curved process	
 <i>A. (C.) acanthophora</i>	
–	Caudal ramus with normal inner margin	3
3	P2 Enp-2 with two seta and spine	<i>A. (C.) vietnamica</i>
–	P2 Enp-2 with four setae and spine	<i>A. (C.) kalima</i>
4	P4 Enp-2 with one seta	5
–	P4 Enp-2 with 2–3 setae	9
5	Caudal ramus with spinules along dorso-inner margin	6
–	Caudal ramus without spinules along dorso-inner margin	<i>A. (C.) antillica</i>
6	P2 Enp-2 with one seta	<i>A. (C.) fluvialis</i>
–	P2 Enp-2 with two seta and spine	7
7	P3 Enp-2 with one apical seta and one outer seta	<i>A. (C.) muscicola</i>
–	P3 Enp-2 with two apical setae	8
8	P5 baseoendopod with spinules along inner margin	<i>A. (C.) lacustris</i>
–	P5 baseoendopod without spinules along inner margin	<i>A. (C.) silvicola</i>
9	P4 Enp-2 with two seta and spine	10
–	P4 Enp-2 with three setae and spine	<i>A. (C.) pilagaensis</i>
10	P2 Enp-2 with two seta and spine	<i>A. (C.) thailandica</i> sp. nov.
–	P2 Enp-2 with four setae and spine	11
11	P3 Enp-2 with four setae and spine	12
–	P3 Enp-2 with five setae and spine	13

- 12 Caudal ramus with spinules along dorso-inner margin..... *A. (C.) vera*
 – Caudal ramus without spinules along dorso-inner margin.....
 *A. (C.) mervini*
 13 Caudal ramus with dorsal seta at 1/2 of length..... *A. (C.) chocoensis*
 – Caudal ramus with dorsal seta at 3/4 of length..... *A. (C.) aliena*

Males

(male unknown for *A. (C.) kalima*, *A. (C.) lacustris* and *A. (C.) pilagaensis*)

- 1 P5 baseoendopod with two setae..... 2
 – P5 baseoendopod unarmed..... 7
 2 Caudal ramus with inner margin produced into curved process
 *A. (C.) acanthophora*
 – Caudal ramus with normal inner margin 3
 3 P4 Enp with one apical seta 4
 – P4 Enp with two apical seta and spine 5
 4 P2 Enp-2 with one seta..... *A. (C.) muscicola*
 – P2 Enp-2 with three setae and spine *A. (C.) fluvialilis*
 5 P3 Enp-3 with one seta..... 6
 – P3 Enp-3 with two setae..... *A. (C.) thailandica* sp. nov.
 6 P4 Enp with two subequal apical setae..... *A. (C.) silvicola*
 – P4 Enp with outer apical seta longer than 2.0× that of inner apical seta.....
 *A. (C.) vietnamica*
 7 P4 Enp with one apical seta *A. (C.) antillica*
 – P4 Enp with two apical seta and spine 8
 8 P2 Enp-2 with three setae and spine 9
 – P2 Enp-2 with four setae and spine..... 10
 9 P3 with two-segmented Enp..... *A. (C.) mervini*
 – P3 with three-segmented Enp *A. (C.) siolii*
 10 Caudal ramus with spinules along dorso-inner margin..... 11
 – Caudal ramus without spinules along dorso-inner margin 12
 11 P3 Enp-3 with one apical seta..... *A. (C.) aliena*
 – P3 Enp-3 with two apical setae *A. (C.) vera*
 12 Caudal ramus slightly longer than wide *A. (C.) chocoensis*
 – Caudal ramus about 2.0× longer than wide..... *A. (C.) sriblingi*

Acknowledgements

The author would like to thank the National Research Council of Thailand (Grant No. 2559A13402007; 2560A13402010; 256108A1340006) for financial support. The author would like to thank the inputs of Dr Santiago Gaviria (Vienna) and Dr Paulo Henrique Costa Corgosinho for suggestions to correct the manuscript.

References

- Borutzky EV (1967) Presnovodnye Copepoda Harpacticoida severnogo v'etnama. Freshwater Copepoda Harpacticoida of north Vietnam. Zoologicheskii Zhurnal 46(7): 1015–1023.
- Chang CY, Kim HS (1992) Two new species of genus *Attheyella* (Harpacticoida, Canthocamptidae) from springs of Korea. The Korean Journal of Systematic Zoology 3: 67–76.
- Chappuis PA (1928) Neue Harpacticiden aus Java. Treubia 10(2–3): 271–283.
- Chappuis PA (1931) Copepoda Harpacticoida der deutschen limnologischen Sunda-Expedition. Archiv für Hydrobiologie, Supplementband 8, Tropische Binnengewässer 1: 512–584.
- Delachaux T (1924) Zur kenntnis der copepodenfauna von Surinam. II. Harpacticiden. Zoologischer Anzeiger 59(1–2): 1–16.
- Gaviria S, Defaye D (2012) A new species of *Attheyella* (*Canthosella*) from Colombia and re-description of *Attheyella* (*Delachauxiella*) *freyi* (Copepoda: Harpacticoida: Canthocamptidae). Zootaxa 3179: 1–38. <https://doi.org/10.11646/zootaxa.3179.1.1>
- Huys R, Boxshall GA (1991) Copepod evolution. The Ray Society, London, 468 pp.
- Janetzky W, Martínez Arbizu P, Reid JW (1996) *Attheyella* (*Canthosella*) *mervini* sp. n. (Canthocamptidae, Harpacticoida) from Jamaican bromeliads. Hydrobiologia 339: 123–135. <https://doi.org/10.1007/BF00008920>
- Kiefer F (1967) Neue Copepoda Harpacticoida aus dem Amazonasgebiet. Crustaceana 13(1): 114–122. <https://doi.org/10.1163/156854067X00134>
- Löffler H (1973) Die harpacticidenfauna des Mt. Kinabalu (Borneo) mit besonderer berücksichtigung der gattung *Maraenobiotus* nebst angaben zur harpacticidenfauna des Gebietes Nuwara (Hochplateau Ceylon). In: Beiträge zur Kenntnis einiger Kleinorganismen tropischer Hochgebirgsseen. Hochgebirgsforschung 3: 5–28.
- Noodt W (1956) *Attheyella* (*Chappuisiella*) *aliena* n. sp., ein copepode tropischer verwandtschaft aus phytohelmen des göttinger gewächshauses. Gewässer und Abwässer 24: 62–69.
- Petkovski TK (1973) Subterrane süßwasser-Harpacticoida von Kuba (vorläufige mitteilung). Résultats des Expéditions Biospéologiques Cubano-Roumaines à Cuba. Editura Academiei Republicii Socialiste Romania, Bucurest 1: 125–141.
- Por FD, Hadel VF (1986) Two new species of *Attheyella* (Copepoda: Harpacticoida: Canthocamptidae) from bromeliads of the Serra da Juréia (Sao Paulo, Brazil). Journal of Crustacean Biology 6(4): 777–788. <https://doi.org/10.1163/193724086X00578>
- Reid JW (1990) *Canthocamptus* (*Elaphoidella*) *striblingi*, new species (Copepoda: Harpacticoida) from Costa Rica. Proceedings of the Biological Society of Washington 103(2): 336–340.
- Reid JW (2001) A human challenge: discovering and understanding continental copepod habitats. Hydrobiologia 453/454: 201–226. <https://doi.org/10.1023/A:1013148808110>
- Walter TC, Boxshall G (2020) World of Copepods database. *Attheyella* (*Canthosella*) Chappuis, 1931. <http://www.marinespecies.org/aphia.php?p=taxdetails&id=714924> [May 1, 2020]
- Watiroyram S, Brancelj A, Sanoamuang L (2015) Two new species of *Elaphoidella* (Crustacea: Copepoda: Harpacticoida) with comments on geographical distribution and ecology of harpacticoids from caves in Thailand. Zootaxa 3919(1): 81–99. <https://doi.org/10.11646/zootaxa.3919.1.4>
- Watiroyram S (2018) *Bryocyclops asetis* sp. n. and the presence of *Bryocyclops muscicola* (Menzel, 1926) from Thailand (Crustacea, Copepoda, Cyclopoida, Cyclopidae). Zookeys 793: 29–51. <https://doi.org/10.3897/zookeys.793.25005>